

SPIN-POLARIZED ELECTRON-SODIUM SCATTERING

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The Electron Physics Group at NIST has an ongoing program studying spin effects in low energy elastic and inelastic electron scattering from sodium. Spin-polarized collision partners are used to perform scattering experiments in which the different contributions of the singlet and triplet channels are measured as a function of incident energy and scattering angle. The spin-polarized incident electron beam is produced in a GaAs polarized electron source, and the spin-polarized sodium atoms are generated by optically pumping with circularly polarized laser light tuned to the $3S_{1/2} \rightarrow 3P_{3/2}$ transition. For elastic measurements, the atoms are optically pumped upstream in the atom beam so they all decay to the spin-polarized ground state before colliding with the electrons. For inelastic measurements, the optical pumping occurs in the collision region, so the electrons have the opportunity to superelastically scatter from spin-polarized excited-state (3P) atoms. The superelastic scattering amplitudes are directly related to those of the equivalent time-reversed inelastic experiment. Besides being spin-polarized, the excited 3P atoms are also oriented by the optical pumping process, so measurements can be made of the spin-dependent angular momentum transfers L_1^S and L_1^T in addition to the spin asymmetry.

In the past, superelastic measurements have been carried out at incident energies of 52.3, 17.9 and 2 eV,¹ which are equivalent to inelastic energies of 54.4, 20 and 4.1 eV. Elastic scattering has been measured at 54.4 and 20 eV.^{2, 3} We present here a new series of measurements with the aim of providing as complete a picture as possible of electron-sodium scattering. Superelastic scattering at 7.9 eV, and elastic at 10, 4.1, 1.6 and 1.0 eV have been measured. Thus we have obtained elastic and corresponding inelastic data at three energies above the sodium ionization limit (5.14 eV), and one energy between the 3P excitation threshold (2.1 eV) and the ionization limit. Additionally, we have elastic scattering data at two energies below the 3P excitation threshold.

As an example, Figure 1 shows the exchange asymmetry $A_{\text{exch}} = (\sigma_{\uparrow\uparrow} - \sigma_{\uparrow\downarrow})/(\sigma_{\uparrow\uparrow} + \sigma_{\uparrow\downarrow})$ at 10 eV total energy for superelastic (3P-3S) and elastic (3S-3S) channels. The solid lines indicate the close-coupling calculations of Mitroy *et al.*⁴ Good agreement is seen for elastic scattering, while large differences are apparent in the superelastic channel. Similar discrepancies exist at 17.9 eV, while calculations at lower energies⁵ show better agreement.

This work is supported in part by the U. S. Dept. of Energy, Office of Basic Energy Sciences, Division of Chemical Sciences.

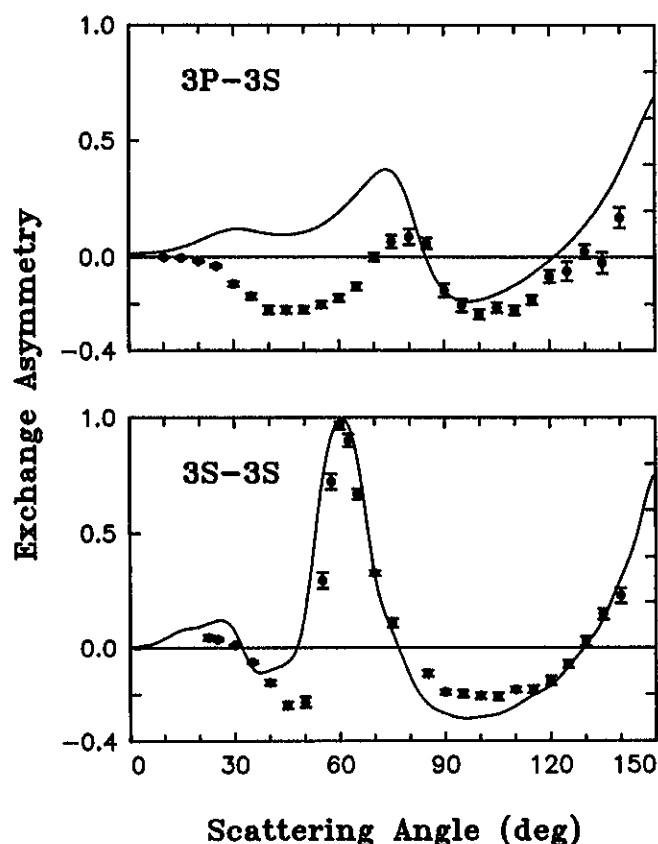


Figure 1: The exchange asymmetry at a total energy of 10 eV for the superelastic (3P-3S) and elastic (3S-3S) channels: •, present results; —, Mitroy *et al.*⁴

References

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